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RESEARCH REPORT

FLIGHT DECK NOISE-EXCLUSION PERSONNEL HELMET (FDPH) EVALUATION

PROJECT NO. NM 001 064.01.16

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U. S. NAVAL SCHOOL OF AVIATION MEDICINE
NAVAL AIR STATION
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JOINT PROJECT REPORT NO. 16

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FLIGHT DECK NOISE-EXCLUSION PERSONNEL HELMET (FDPH) EVALUATION

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SUMMARY

Eight FDP Helmets were evaluated as to their noise attenuation characteristics under three general sound conditions; (a) the total audible frequency spectrum at each frequency in the spectrum, (b) 124 db of JRB noise recorded in the cockpit at the co-pilot's right ear with the window open, and (c) 124 db of American Standards Association (ASA) "white" noise. A plaster dummy head was fitted with a miniature condenser microphone within the head and whose opening to the outside simulated the external auditory meatus. The microphone diaphragm was in the approximate position of the ear drum. The frequency response curves were made with the head in a position in front of the loudspeakers and then with a helmet on, the head remaining in the same position. Attenuation values, when the ambient noise was the JRB or ASA white noise, were obtained using the above procedure.

CONCLUSIONS

1 - None of the FDPH are effective in attenuating noise frequencies below 500 cps.

2 - Of the eight helmets, Number 4 had the greatest attenuation characteristics. The rest could be ranked: No. 3, No. 7, No. 5, No. 6, No. 1, No. 8, No. 2.

3 - The helmet with the greatest mass had the better attenuation qualities.

4 - Occluding the ear canal by a standard ear warden appears to offer greater protection than do any of the helmets.

INTRODUCTION

Increased noise levels, especially those encountered during jet aircraft operations from carrier flight decks, probably exceed safety limits for personnel exposed to the noise for long periods. The Chief of the Bureau of Aeronautics requested that some prototype models of Flight Deck Noise-Exclusion Personnel Helmets be tested as to their noise-exclusion properties. Realizing the importance medically and perhaps psychologically of protection from acoustic trauma resulting from high level noise, this evaluation was undertaken with interest.

PROCEDURE

In order to insure that all helmets would be evaluated under conditions that were as nearly identical as possible a plaster dummy head was secured and fitted with a miniature condenser microphone (calibrated) simulating a right ear. The opening to the microphone closely approximated the diameter and length of the external auditory meatus with the diaphragm of the microphone in the position of the tympanic membrance. (See Figures 1, 2, 3, and 4). The dummy head was packed with fiberglass and the two hemispheres of the head were separated in the mid-sagittal plane by a sheet of porous sponge rubber. This minimized the resonance characteristics of the device and gave approximately 25 db attenuation between the two hemispheres. A further precaution was to insert a large rubber cork in the hollow neck opening.

A response curve covering the audible spectrum was run without a helmet in place with the plaster head (the right ear) 36 inches from the floor and 70 inches directly in front of a bank of four low frequency and four high frequency loud speakers (one-fourth of the total noise generator). The loudspeakers and the head were in a large sound proofed room. The analyzing equipments were in a control room. A response curve was run prior to the fitting of each helmet on the head. A second curve was made after each helmet was in position and both curves appear on the same chart (see Results, following). For the overall noise level measurements two types of sounds were used; (1) 124 db of recorded JRB, twin-engine noise and (2) 124 db of American Standards Association "white" noise. The 124 db was measured from the output of the microphone in position within the head and the attenuation was read from a meter, plus a graphic recording, after each helmet was positioned.

Each helmet was arbitrarily given a number, more or less at random as it was drawn from the shipping carton, 1-8, and will be so identified in the tables and figures to follow. Photographs of the helmets in position and their identifying numbers are found in Figures 5 through 12. Since the pictures are not in color a brief physical description follows:

Helmet One (1): Green in color. The protective covering over the ears is a NAF-48490-1 earphone cushion with a second chamois ring, or doughnut, secured to the doughnut ring of the earphone cushion. A wooden plug is inserted in the normal place of a receiver.

Helmet Two (2): A standard headband, Navy No. 49510, attached to the same type of "double-doughnuts" as aboye but with a rubber cork in place of the receiver. The cork is held in place by a plastic rod.

Helmet Three (3): Blue in color. The cushions over the ears are the same double-doughnut type with a white, semi-rigid, sponge rubber or sponge plastic plug in place of the receiver.

Helmet Four (4): Standard headband, Navy No. 49510, with a double-doughnut type earphone cushion. Regular ANB-H-1 receiver fitted in place.

Helmet Five (5): Brown in color. The ear protectors are the double-doughnut type with wooden plywood plugs in place of the receivers.

Helmet Six (6): Yellow in color. This is the one device that was not basically of the double-doughnut construction. The ear coverings are filled chamois leather bags, or "puffs", held in place by web straps onto the outside of the cloth helmet completely covering the ears.

Helmet Seven (7): Reddish-Brown in color. The double-doughnuts cover the ears and have a wooden plywood plug in place of the earphone. There is a small hole (2 cm) in the center of the wooden plug filled with what seems to be plastic wood.

Helmet Eight (8): White in color. The double-doughnut ear protector has a plug of three-layered black leather in place of the regular earphones.

Two additional evaluations were also made. The first was the use of a probe tube on a calibrated miniature condenser microphone when one of the helmets (the one which seemed to have the better attenuation characteristics) was fitted on a human head giving the noise attenuation at the entrance to the ear canal. The second was to use a standard V-51R ear warden to occlude the "ear" opening on the experimental plaster head and to obtain the same information as on the helmets. A standard HS-33 headset was also placed over the synthetic ear with the ear warden in position.

EQUIPMENT

The two basic general circuits were the recording and the noise generating.

(1) The recording is shown by a block diagram, Figure 13. The sound transducer, or artificial ear, (See Figure 3) was an Altec-Lansing 21-C, calibrated, on a 157 base. This provided the signal which fed a Sound Apparatus Automatic Frequency Response Recorder or a Hewlett-Packard 400-C Vacuum Tube Voltmeter which was checked continuously and graphically by an Audio Devices' Logger.

(2) The noise generating circuit is shown by block diagram Figure 14. The three types of ambient signals were introduced into the large sound-room by three generators which fed the amplifying system and loudspeakers. The recorded JRB noise by the Ampex, Model 401-A, the ASA white noise by the H. H. Scott Noise Generator, Type 810-A, and the continuous sine wave (pure tone) by a General Radio Beat-Frequency Oscillator, type 1304-A.

The double audio-frequency response curves were all made with a helmet in position carefully covering the entire ear. The same procedure was done for each over-all noise measurement. Continuous checks were made to insure that the ambient noise sound-pressure levels remained the same.

RESULTS

The attenuation characteristics of each FDPH over the audible spectrum are found in Figures 15 to 22. These are the actual curves from the Automatic Frequency

Response Recorder. A summary of these curves are below in Table I.

Table I: Attenuation in DB at Each of 11 Discrete Frequencies

Helmet No.

Frequency	1	2	3	4	5	6	7	8
20 cps	0	0	-3	0	-2	0	0	0
50	0	0	-1	1	-1	0	0	0
100	-1	-2	-2	-1	-2	0	2	0
250	4	6	0	-1	1	1	-2	0
500	5	3	9	12	14	3	12	1
1000	17	11	19	22	22	6	18	11
2000	11	16	16	20	14	13	15	7
4000	15	11	16	20	17	12	15	12
8000above	20	10above	28above	30above	25above	27above	24above	20
10000 "	20	11 "	28 "	30 "	25 "	27 "	24 "	20
15000 "	20above	20 "	28 "	30 "	25 "	27 "	24 "	20

It would appear that of the eight helmets Number 4 gives the greatest protection. None of the helmets, however, are successful in attenuating frequencies much below 500 cycles per second. As far as the relative attenuation of the total audible spectrum of the eight helmets they would probably rank as follows: 1, number 4; 2, number 3; 3, number 7; 4, number 5; 5, number 6; 6, number 1; 7, number 8; 8, number 2.

The measurements under conditions of 124 db of recorded JRB noise and 124 db of ASA white noise are summarized in Table II following.

Table II: Attenuation in DB of the FDPH Under Two Type Noises

at 124 DB Level

Helmet	JRB Cockpit Noise	ASA White Noise
1	7.5	9.0
2	7.0	6.5
3	11.0	13.0
4	10.0	15.0
5	7.5	10.0
6	5.0	2.5
7	13.0	9.0
8	4.5	6.0

It appears that the rankings given from the results of the frequency response curves would be changed but little if the data in Table II were to be ranked. Helmet 4 seems slightly better than the others if both type noises are taken into account.

One of the experimenters was fitted with Helmet 4. A microphone probe tube was inserted into the doughnut with the tip, or open end, of the tube positioned in the opening of the ear canal at the plane of the tragus. The closed end of the probe tube fitted the microphone button of Altec 21-C, calibrated, condenser microphone. The attenuation of the helmet on the human head was 10 db for the JRB noise and 12 db for the ASA white noise. These results are but little different from the attenuation readings of the same helmet positioned on the plaster head.

The results of the attenuation characteristics over the audible spectrum, under the same conditions as the FDPH described above, of the V-51R ear defender are shown in Figure 23. The ear warden was placed in the artificial external auditory meatus and seated similarly to the way it would be inserted in a human ear canal. A summary showing the attenuation characteristics of the V-51R at the same discrete frequencies as in Table I are given in Table III following.

Table III: Attenuation in DB at Each of Eleven Discrete Frequencies at 124 DB S.P.L.

(V-51R Ear Warden)

Frequency	Attenuation
20 cps	0
50	1 db
100	1 db
250	11 db
500	25 db
1000	19 db
*2000	*42 db
4000	42 db
8000	63 db
10000	64 db
15000	60 db

*All values for frequencies above 2000 cps were obtained by extrapolating the attenuation slope which appears to be approximately 15 db per octave above 1000 cps.

In the two ambient noise conditions of 124 db of continuous JRB and ASA noise the following attenuation values were noted.

	ASA White Noise	JRB Noise
V-51R	20 db	18 db
Lee Sonic EAR-VALV	9 db	10 db
Helmet #4 with V-51R	20 db	18 db

Comparison of the above values with those of Table II is invited; also comparison of Tables I and III.

DISCUSSION

Of the eight helmets Number 4 has slightly better attenuation characteristics than some of the others. The one factor that may contribute to its sound attenuation characteristics could be the increased mass. It is known that sound, and particularly low frequency sounds, can only be absorbed, hence attenuated, by materials whose mass per unit volume is high. Future design characteristics are indicated by the above data that protection devices probably need increased mass for higher attenuation or that some provision be made to occlude the ear canal.

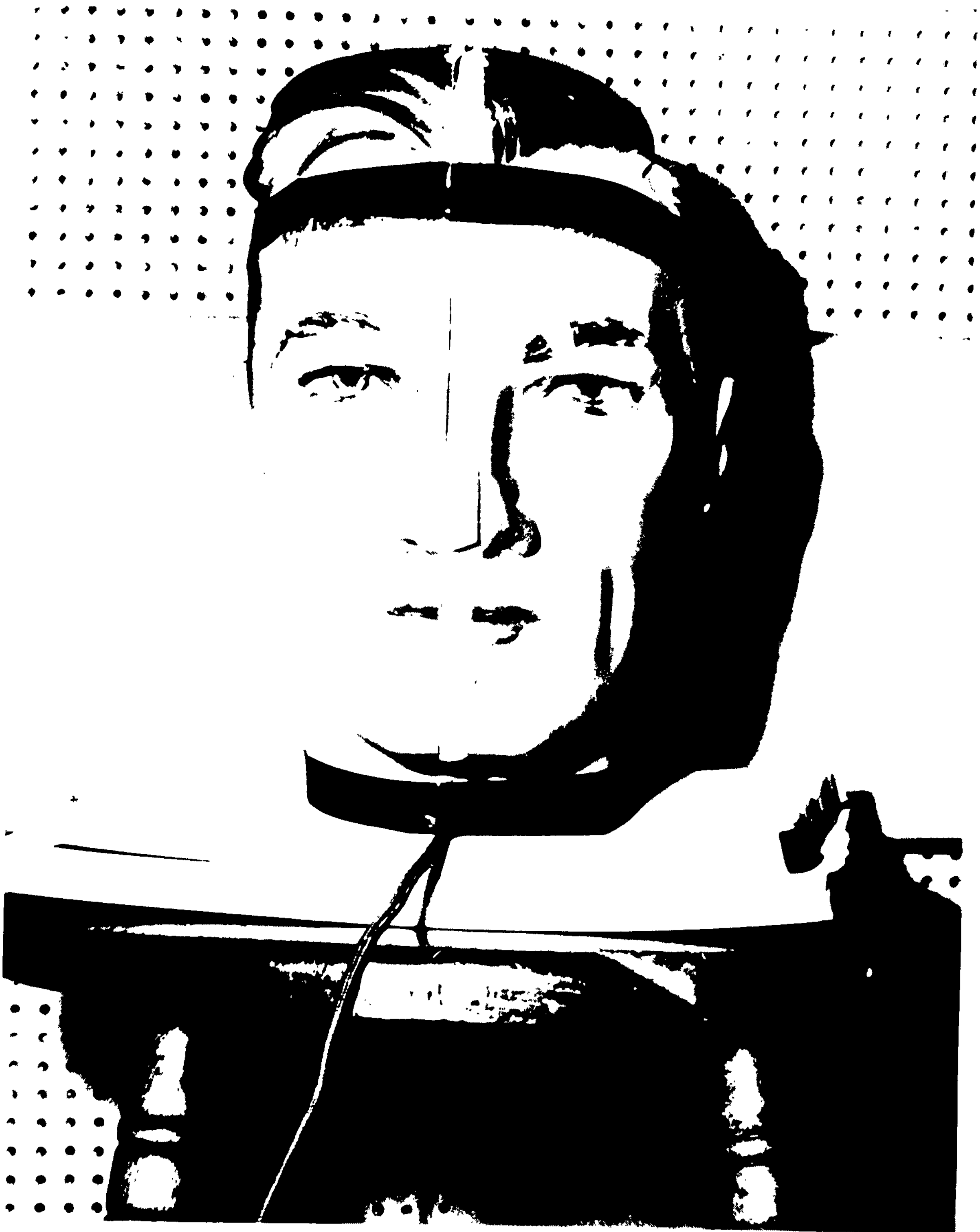


Figure I

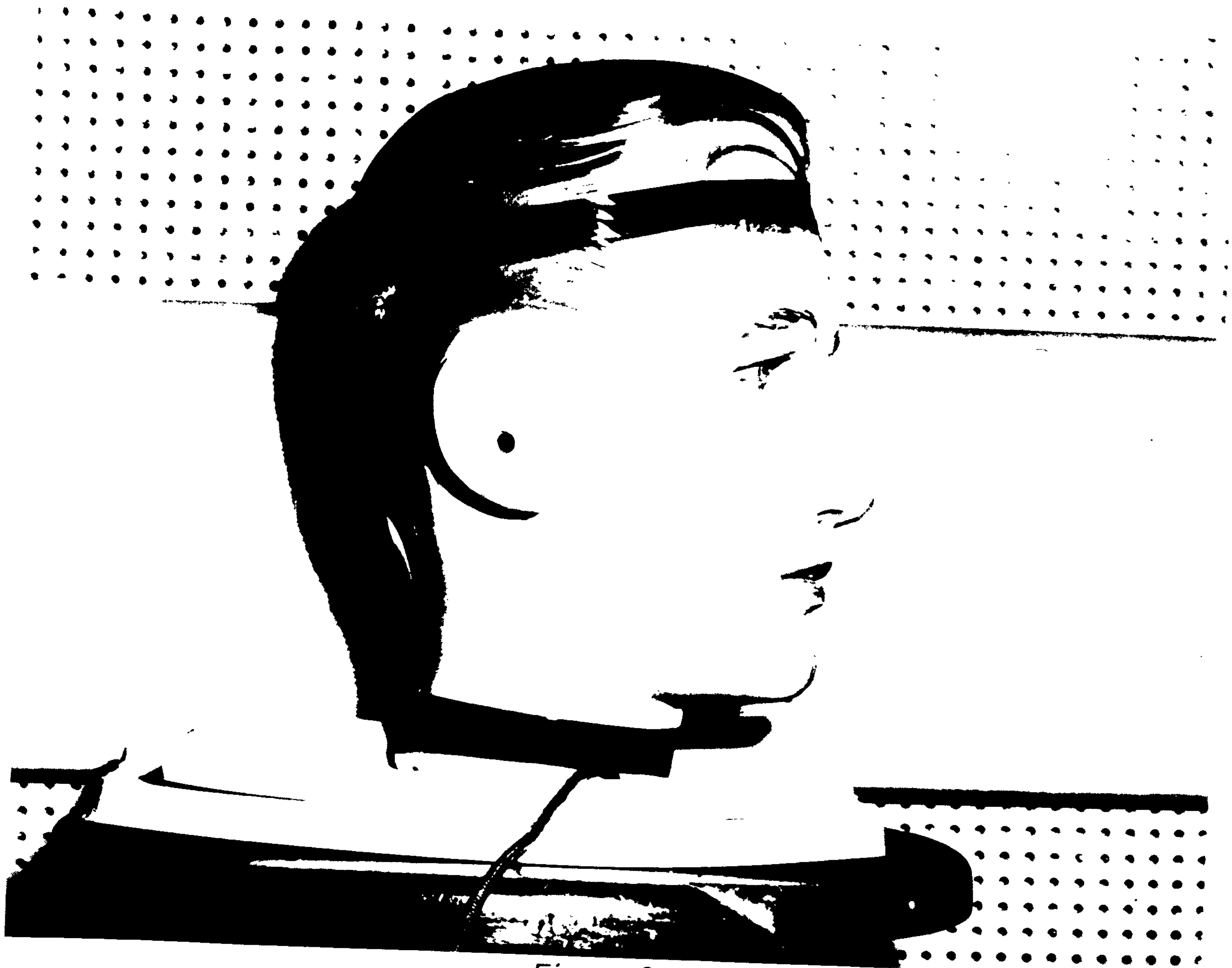


Figure 2

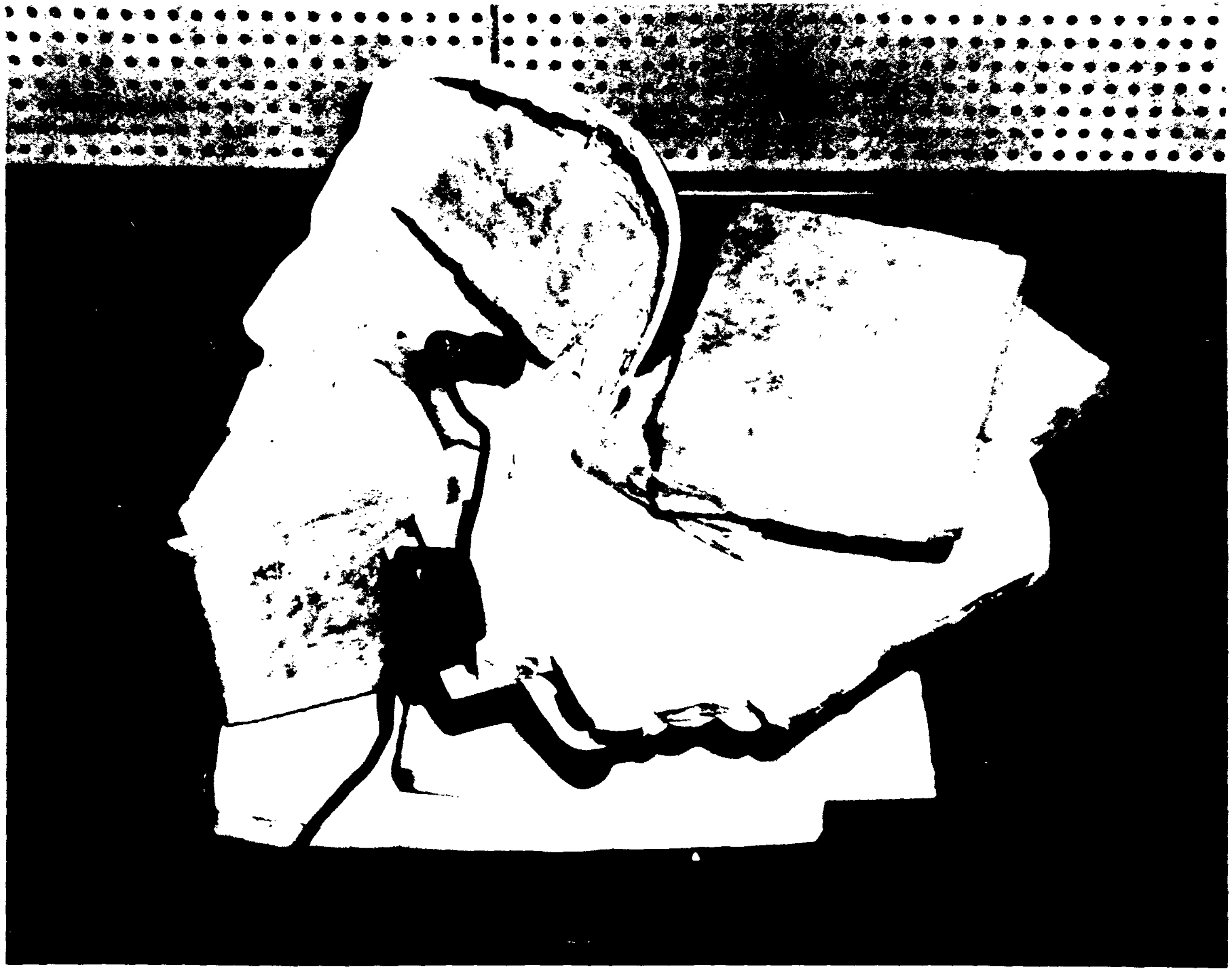


Figure 3

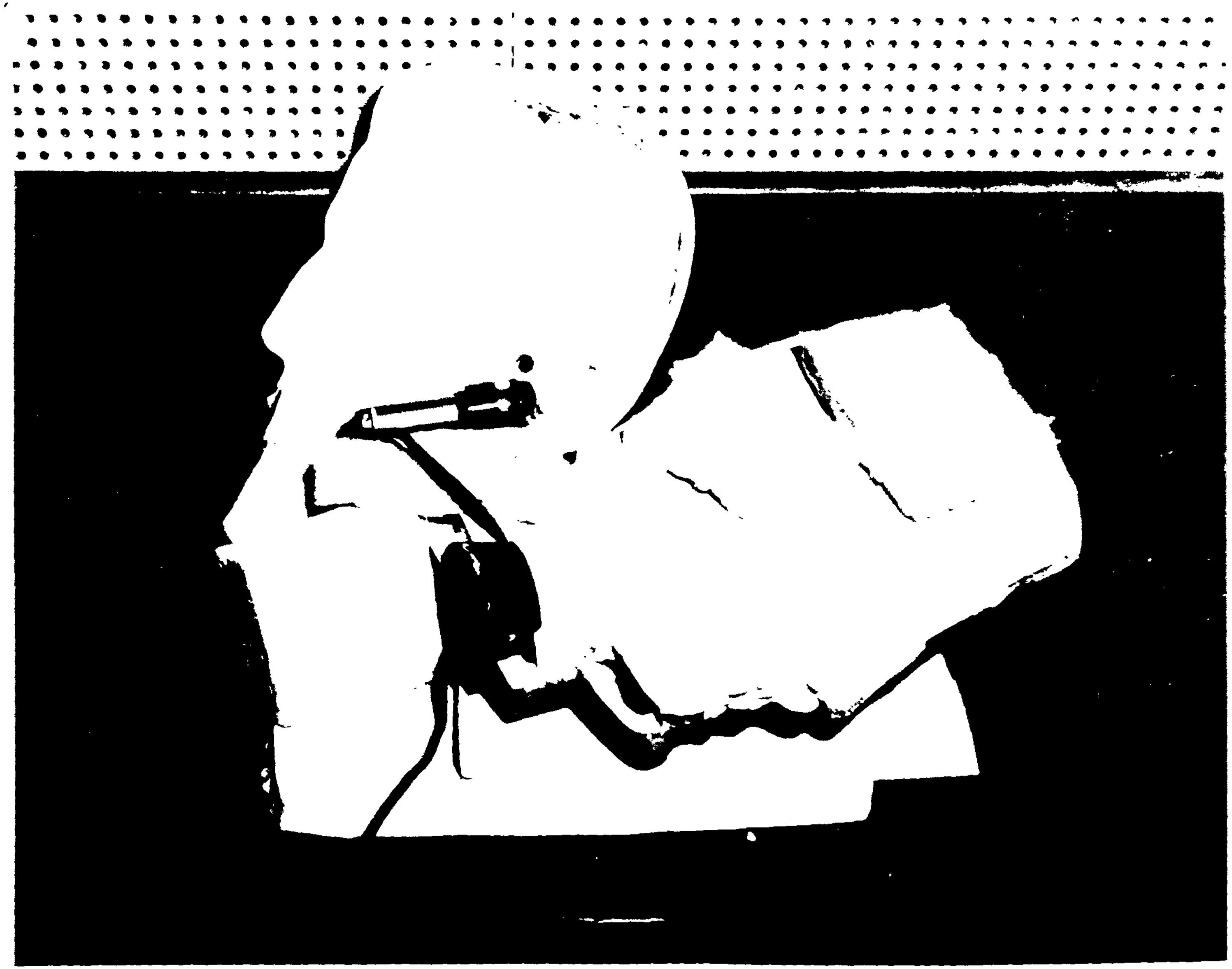


Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

Figure II

Figure 12

Figure 13: RECORDING CIRCUIT—BLOCK DIAGRAM

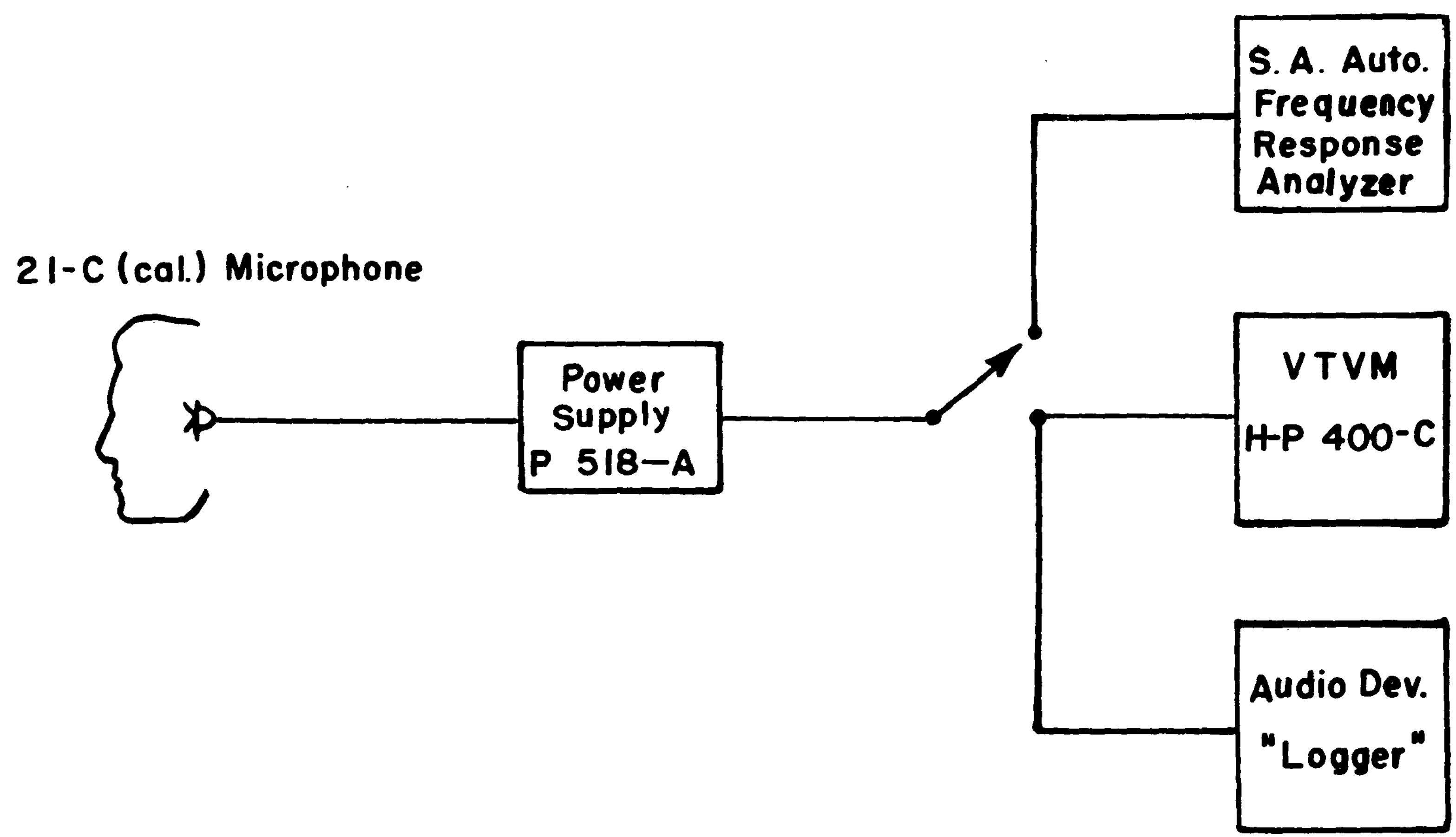
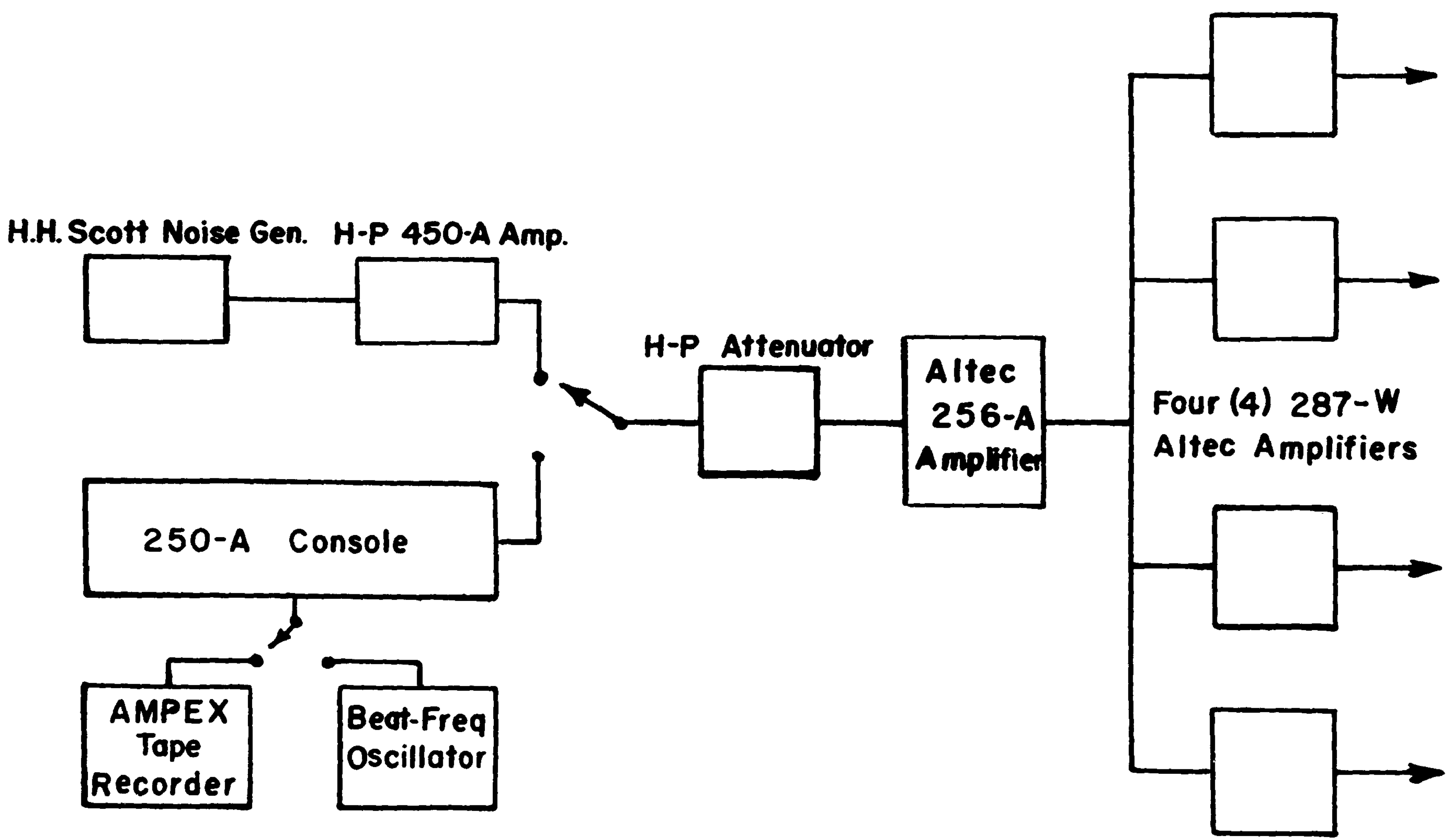
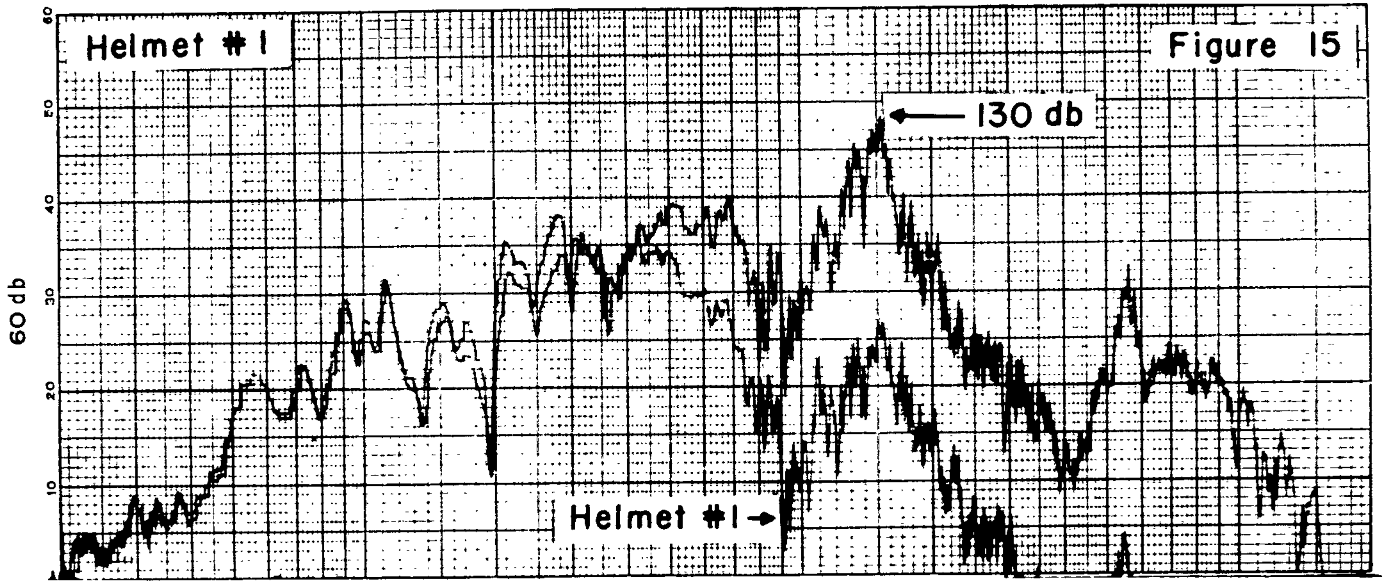
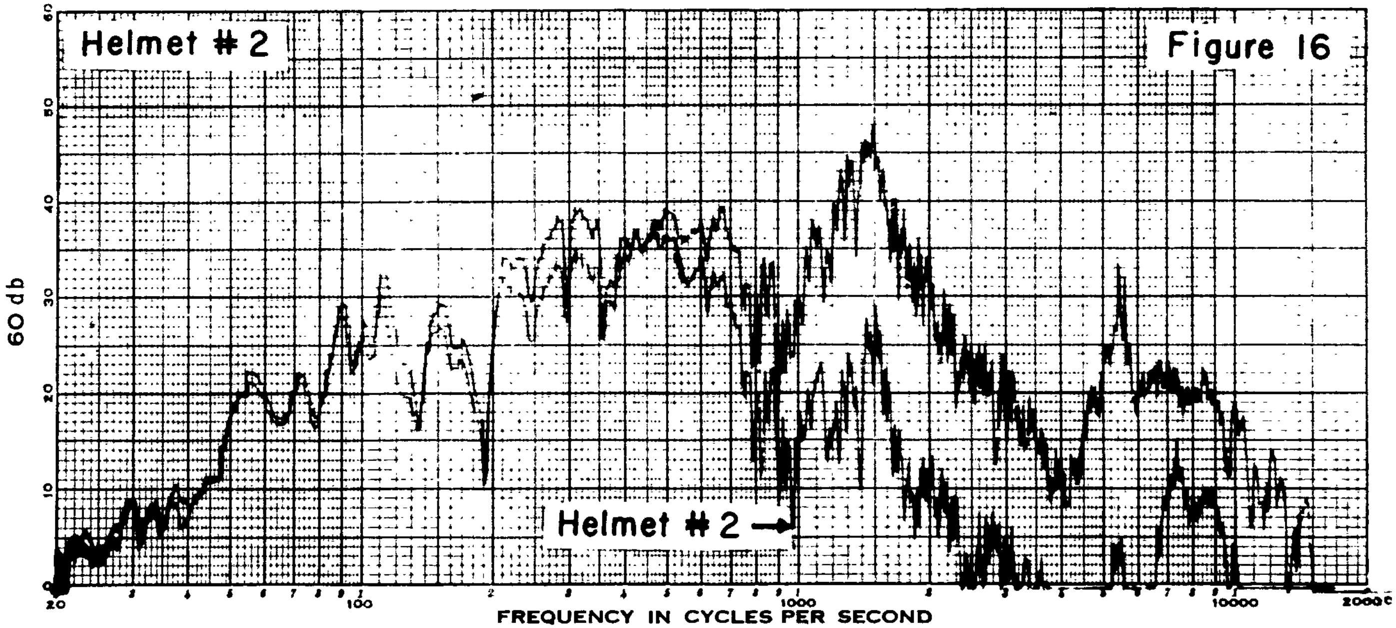
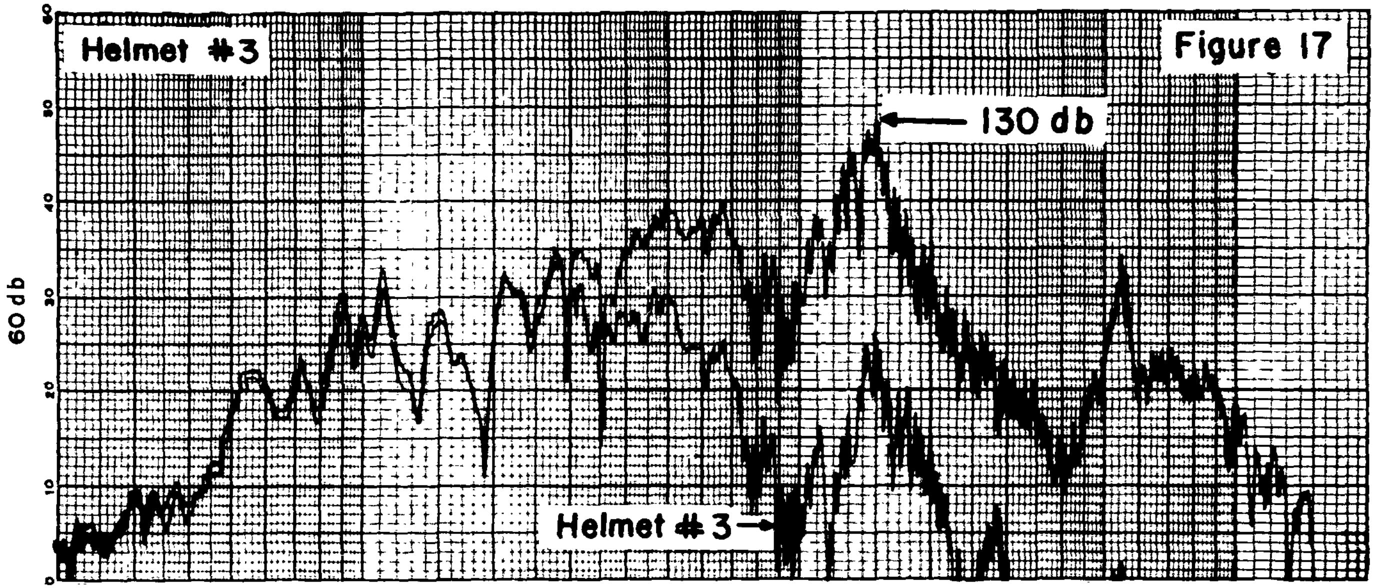


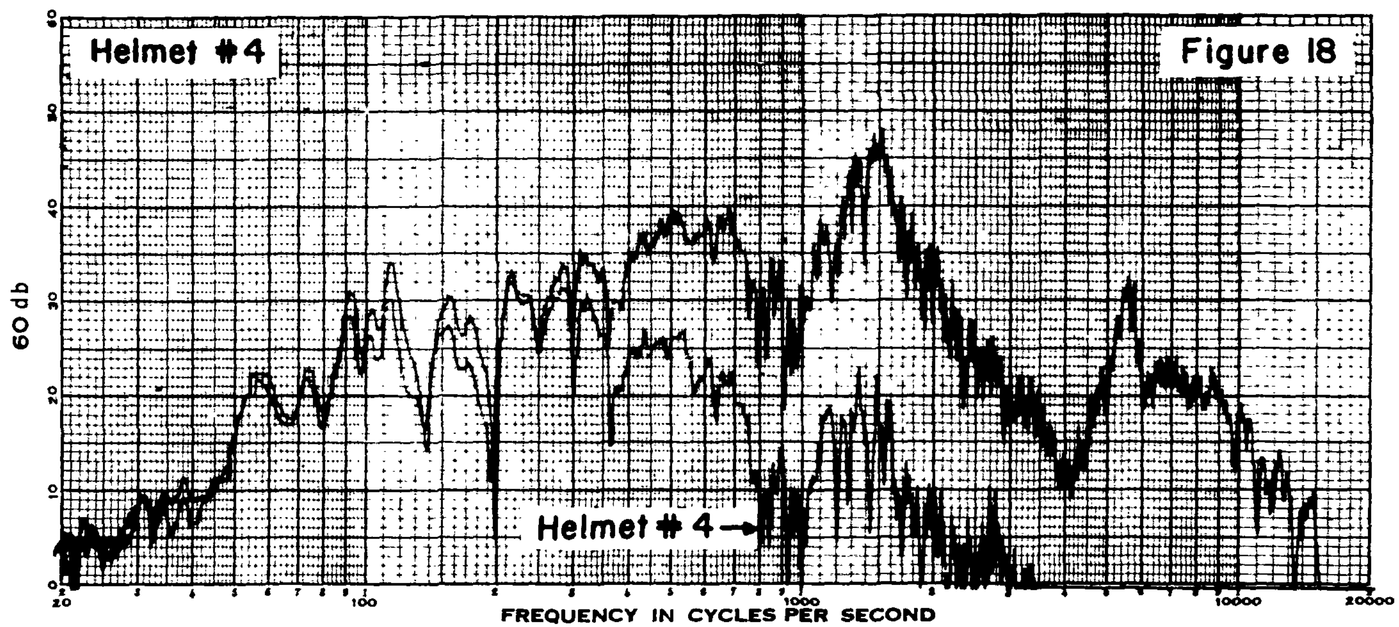
Figure 14: NOISE GENERATOR — BLOCK DIAGRAM

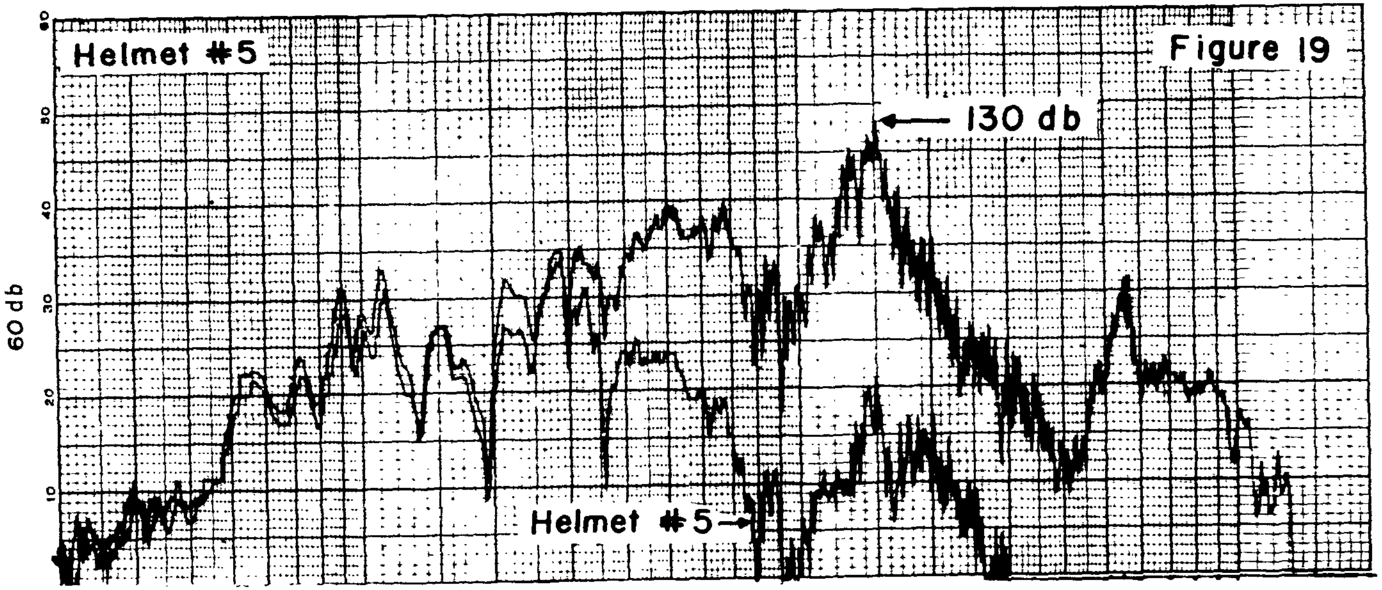


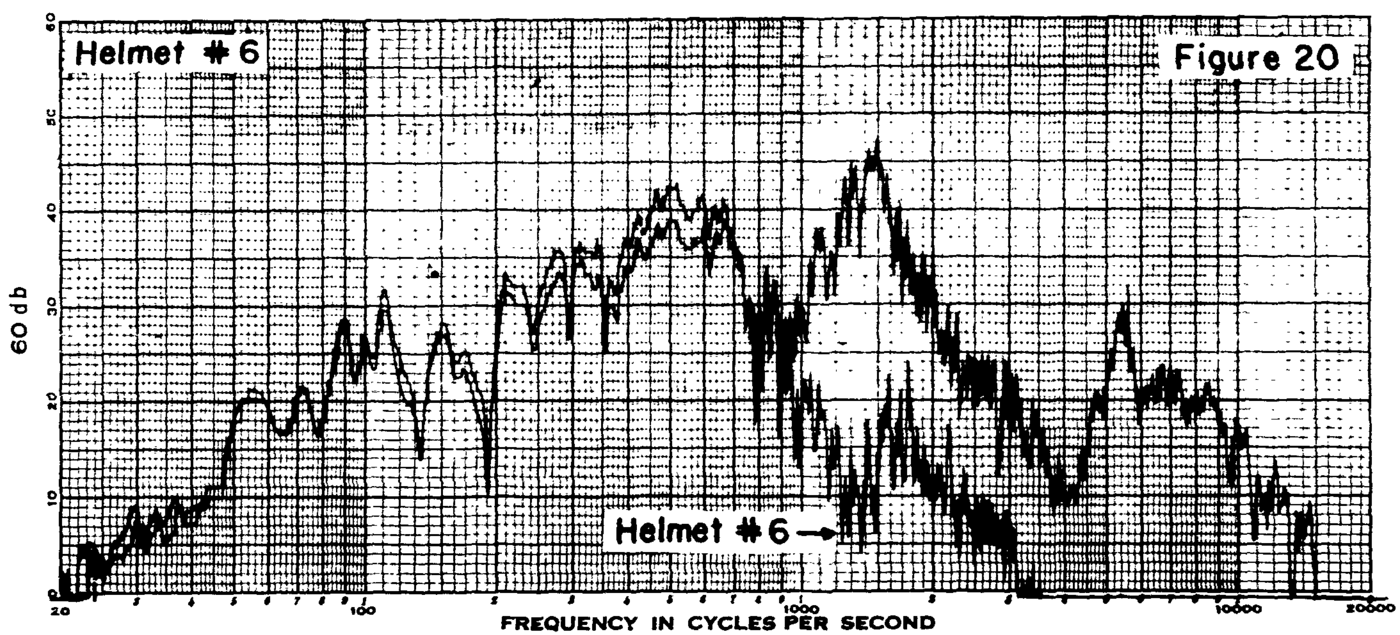

Helmet # 1
Figure 15
130 db
Helmet #1
60 db

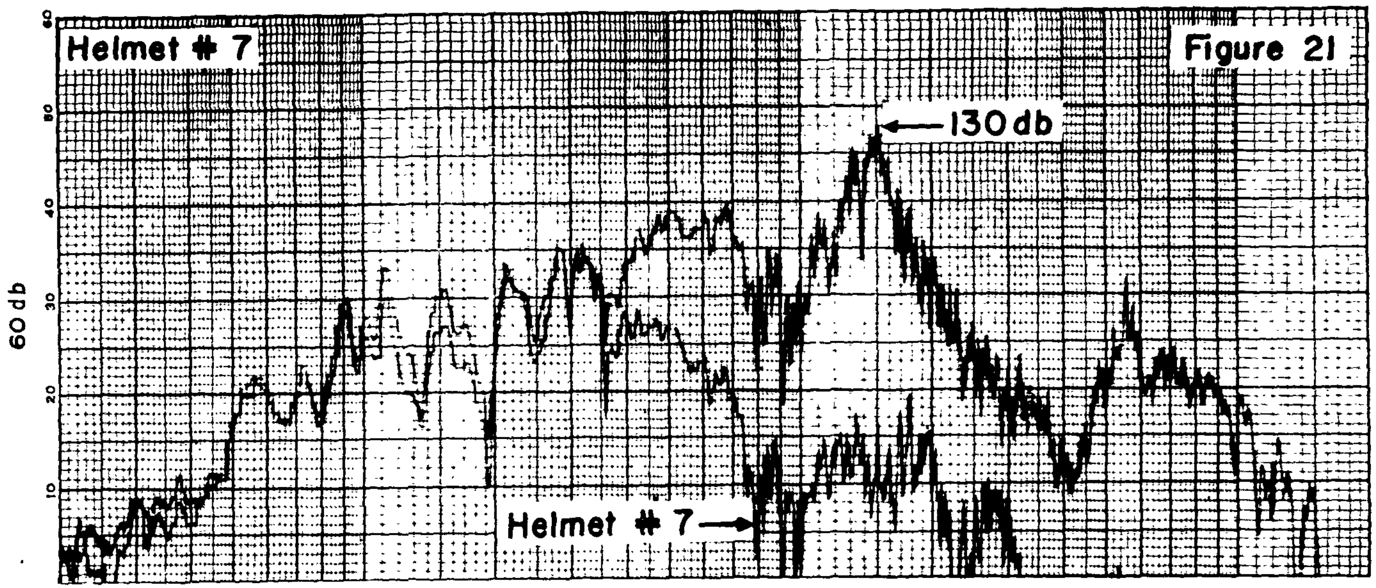

Helmet # 2
Figure 16
Helmet # 2
60 db
FREQUENCY IN CYCLES PER SECOND

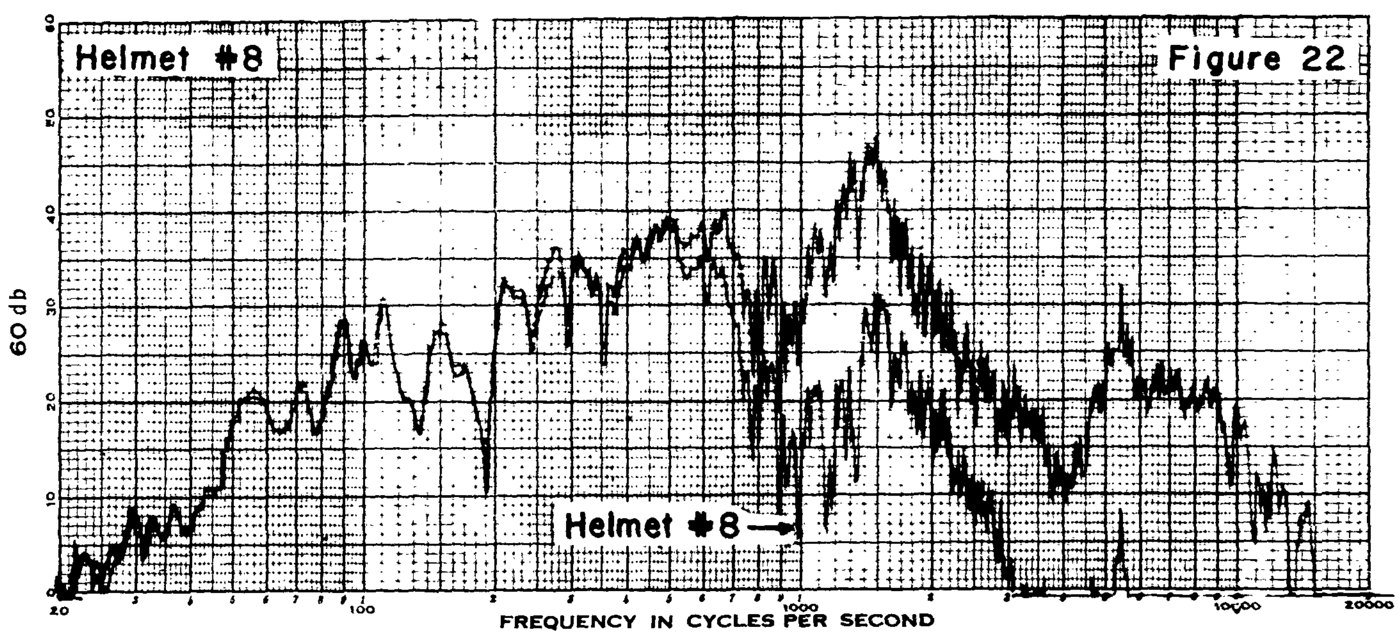

Helmet #3
Figure 17
130 db
Helmet #3
60 db


Helmet #4
Figure 18
Helmet #4
60 db
FREQUENCY IN CYCLES PER SECOND


Helmet #5
Figure 19
130 db
Helmet #5
60 db
10
20
30
40
50
60


Helmet # 6
Figure 20
Helmet # 6
60 db
10
20
30
40
50
60
20
100
1000
10000
20000
FREQUENCY IN CYCLES PER SECOND


Helmet # 7
Figure 21
130 db
Helmet # 7
60 db
10
20
30
40
50
60


Helmet #8
Figure 22
Helmet #8
60 db
10
20
30
40
50
60
20
100
1000
10000
20000
FREQUENCY IN CYCLES PER SECOND

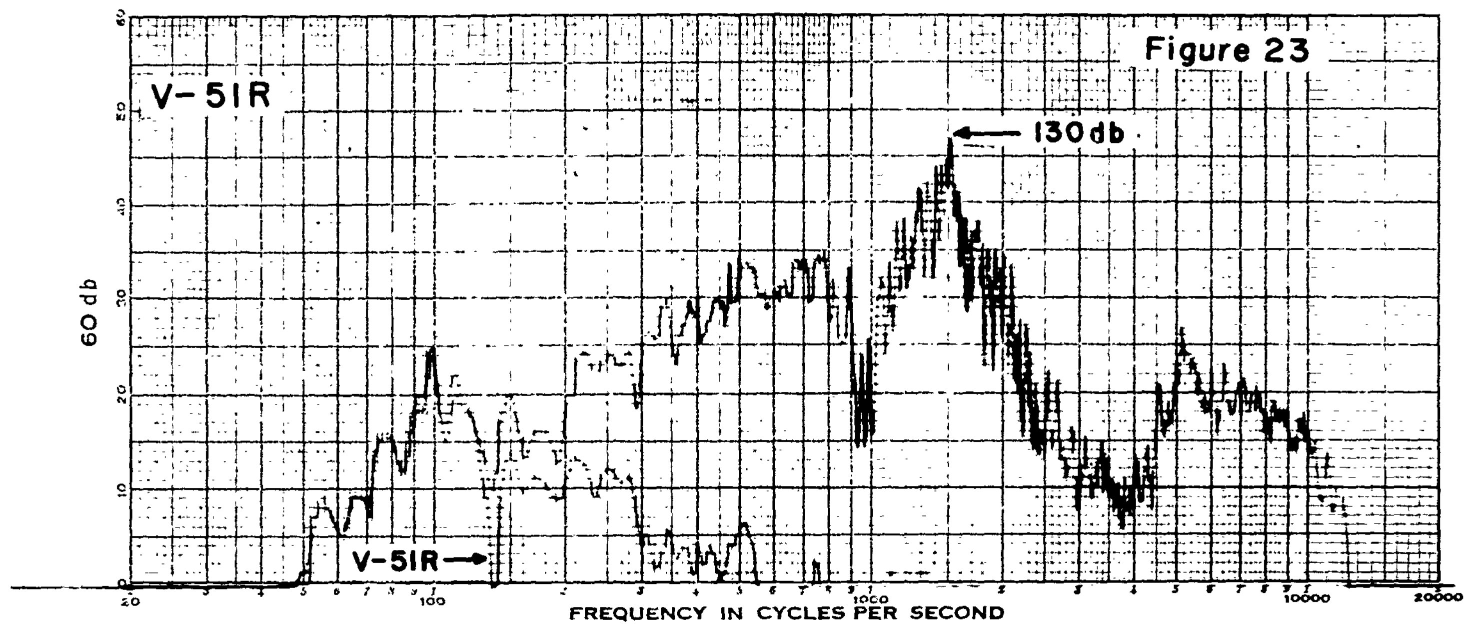


Figure 23
V-51R
130db
V-51R
60 db
0
10
20
30
40
50
60
20
100
1000
10000
20000
FREQUENCY IN CYCLES PER SECOND